

- I. *A Description of a new Invention of Bellows, called Water-Bellows, by Martin Triewald, F. R. S. Captain of Mechanics, and Military Architect to his Swedish Majesty; communicated to the Royal Society by Sir Hans Sloane, Bart. Pres. R. S. &c. See the Fig. in Tab. prefixed.*

SINCE scarce any thing, especially what relates to Mechanical Contrivances, may be said to have attained such a Perfection as not to want any Improvement, it may not be amiss to undertake the Improvement of those Inventions that Time out of Mind have been practised, as well as to invent Engines to do those Services that have been effected by mere Labour. Of this the last Age has produced not a small Number; yet he that first undertook to convert Leathern *Bellows* into Wooden, which are made use of in this Country at all our Iron Forges and Furnaces, &c. has procured as great a Benefit to this Kingdom, as ever any Inventor of Ease and Conveniency in the Necessaries of Mankind.

I have now the Honour to propose such *Bellows*, which as to their Effect will not be inferior to the last-mentioned, but far more advantageous, not only for Iron Furnaces, but likewise for many other Smelting-works requiring large *Bellows*.

It will doubtless seem in the Beginning a little strange, that Water should be able to blow the Fire, but he, that has read the *Philosophical Transactions*,

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and seen the Invention there described, and made use of in *Italy* at *Tivoli*, and several other Places, called *Soffi d'Acqua*, and doth with Attention consider the following Description, will, I hope, be convinced, that this new Invention of *Water-Bellows* is built on the very self-same Foundation, to which Leathern and Wooden *Bellows* owe their Use and Being, and will in several Cases prove of more signal Service.

These *Water-Bellows* A and A, represented in the Figure annexed, are made of Wood, not unlike the Shape of Diving-Bells, in the Form of a *Conus Truncatus*, and consequently wider below than at top, where they are furnished with close Heads B and B, but at the lower Ends E and E, quite open. At the Heads B and B, are two Valves V and V, which open inwardly, and are made like the Claps of other *Bellows*, with their Hinges, and the Valves themselves covered with Hatters Felt, and are shut by an easy Steel Spring, till the Air from above opens the same, which happens only when these *Bellows* receive their Motion upwards; but are shut by means of the Pressure of the Air within, when they sink down into the Water. On the very same Heads are two pliable Leathern Tubes R and R, fixed one at the Top of each *Water-Bellows*, which Tubes are made and prepared in the same manner as those used in Water-Engines for extinguishing of Fire. These Leathern Tubes or Pipes reach from the *Bellows* to Wooden Tubes T, T, which carry the Wind into the Iron Furnace M, or any other Place, according to Pleasure.

These *Bellows* are likewise provided with Iron Chains k, K, which are fastened to two Sweeps S, S, by which means they hang perpendicular from the Beam

Beam of the Balance, and at the same Distance from the Centre of its Motion C.

On the Balance are two sloping Gutters F, F, into which the Water alternately runs from the Gutter G, and so gives Motion to the whole Work; so that these last-mentioned Gutters F, F, do the same Service as an Over-shot, or any other Water-wheel, and cost a great deal less, but give as even and regular a Motion, as any *Pendulum*, for measuring of Time; for as soon as so much Water runs into either of the afore-mentioned inclined Plains of the Gutters, so that the *Momentum* of the Water exceeds the Friction near the Centre of Motion C, the Gutter immediately moves down with a Velocity increasing, till the Balance meets with the Resistance of the Wooden Springs H and H, and at the same time raises the opposite *Water-Bellows*, or that *Bellows* which is fixed under the opposite Gutter. In the same Moment again as the said Gutter begins its Motion, being come down on the Spring, delivers all the Water it has received; at the very same time the Water begins to run into the opposite Gutter, which receives its Load of Water almost as soon as the former is emptied; so that one of the Gutters does its Effect, as soon as the other has done his, and this alternately one after another.

These sloping Gutters on the Balance do therefore all the Service and Effect which a Water-Wheel does in working the ordinary *Bellows*, and that by means of the Power which the Water applies to the Wheel of giving the ordinary *Bellows* their Motion, after the same manner does the Water here impower the sloping Gutters to do the same Work.

But as for the manner and by what means these *Water-Bellows* are fit to blow the Fire, and to perform the same as Leathern or Wooden *Bellows*, there is no other Reason, but the very self-same wherein the Effect of the ordinary *Bellows* consists. For an ordinary pair of *Bellows* blow for no other Reason, but that the Air, which enters the *Bellows*, and which they contain when raised, is again compressed or forced into a narrower Space, when the *Bellows* close: Now since the Air, like all other Fluids, moves to that Place where it meets with the least Resistance, the Air must consequently go through the Opening which is left for the same, with a Velocity proportioned to the Force by which the Air is compressed, and must of necessity blow stronger or weaker, in regard to the Velocity by which the Top and Bottom of the *Bellows* meet; the Blast also will last in Proportion to the Quantity of Air, that was drawn into the *Bellows* through the Valve or Wind-clap.

This does after the same manner happen in our *Water-Bellows*; for the Air, which they contain, cannot force itself down through the Water more than through a well-secured Deal-board with Pitch; when the *Bellows* are lower'd down into the Water, the Air which they contain must necessarily be compressed by the Water, which rises alternately into the *Bellows* A and A; so the Air must recede and go through the Leathern Tubes R, R, where the Air meets with the least Resistance. From all which it undoubtedly follows, that the larger, that is to say, the more Air these *Water-Bellows* are made to contain, and the greater the Velocity is by which they are made to descend into the Water, so much greater is their

their Effect; and that the Effect which they are able to perform, must be equal to that of Leathern or Wooden *Bellows* of the same Capacity, in containing an equal Quantity of Air.

As to the Advantages which this new Invention has in regard to those used hitherto, it is a known Thing, that the Power which works your common *Bellows* used at Iron Furnaces, must be sufficient not only to compress the Bellows, but at the same time to force down the Leaver with its Weight or Counterpoise; which Leaver serves again to raise the *Bellows*, when the Cog or Button on the Axle-tree of the Water-Wheel slides off from the *Bellows-tree*, so that the Power must be sufficient at once to produce two different Effects; whereas these new *Water-Bellows* require scarce any greater Power but what is necessary to overcome the Friction near the Centre of Motion, or the Axis C; for in this my Invention an Advantage is obtain'd, which very rarely happens in Mechanics, viz. *That the Weight to be moved is, as here, on the Balance in Æquilibrio*; since the *Bellows A* and *A* cannot be otherwise conceived than as two equal, though heavy Weights in a pair of Scales, which balance one another, although their Weight be ever so great; so that, if each of these *Bellows* should weigh a Tonn, they must still equiponderate; which is so much easier attain'd to, since it requires very little Art to make them both of a Weight, and order them at equal Distances from the Centre of Motion. It is consequently known how small a Power is requir'd to set the Scales of a Balance with equal Weights in Motion, notwithstanding the Weight may be as great

as possible; all which may with good Reason be applied to these *Water-Bellows*.

And though it cannot be denied, but that the *Bellows* which sinks down into the Water-hole or Sump N, grows so much lighter, as it loses of its Weight in Water, by which means the *Water-Bellows* to be raised grows so much heavier, as the former loses of its Weight by being let down into the Water; yet this is compensated, if we consider, that the Water which falls down along the sloping Gutter, acquires a Power of a falling Body; which Power increasing in the same Proportion as the *Bellows* to be raised grows heavier, this Power suits admirably well the Weight to be raised; for the *Bellows* that sinks down into the Sump N, does not at once lose its Weight in the Water, but gradually as it comes deeper into the same; and after the same manner the ascending *Bellows* does not grow at once heavier than the other, but gradually, growing heaviest just when the lowermost Edge gets even with the Surface of the Water; and that happens at the same Instant of Time when the Power of the Water in the sloping Gutter is at the highest pitch, or has received its greatest *Momentum*.

This shews, I hope, very plain, that the Power required to work these *Water-Bellows*, is far less, and consequently less Water will be consumed in working these *Bellows* than those commonly used; and again, that an Iron Furnace, which for want of Water to work the common *Bellows*, cannot be kept at work longer than six Weeks, though it be provided with all other Necessaries, may, by means of  
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such *Water-Bellows* as here described, be kept at work at least as long again.

It is farthermore a known thing to Miners, of what prodigious Loss and Inconvenience it is, when the Hearth or Mouth of an Iron Furnace is placed low, in a wet and damp Place, which they oftentimes are forced to do, in regard to the Axle-tree of the Water-Wheel which works the *Bellows*; for which Reason such Furnaces as stand in the like moist Places, give daily considerably less Iron, than others which are better situated. There is likewise not a small Difficulty to find a fit Situation for such Iron Furnaces where Iron Guns are cast, and require deep Pits under the Mouth of the Furnace: But by means of this new Invention of *Bellows*, one may be at Liberty to place the Mouth of the Furnace as high as one pleases, seeing it is very easy to guide the Blast by means of Wooden or Leaden Tubes, as far as necessary, and in a proper Direction into the Furnace; which Advantage cannot so easily be obtain'd by those *Bellows* in common use.

Further, this may be accounted as no small Advantage which these *Bellows* afford, in being of so very easy a Structure, that any Carpenter at first Sight is able not only to construct the whole Engine, but easily repair every Part of the same, requiring at the same time the least Repairs of any that can be used; and if the *Bellows* should be cast Iron, they would last for several Ages; and when cast strong, they would not require any Weight to sink readily in the Water. One might cause them to be cover'd with Lead, or make them of thin Copper with a thick Leaden Hoop at top, to make them sink. As for their Shape, it is not absolutely necessary they should be of the same as  
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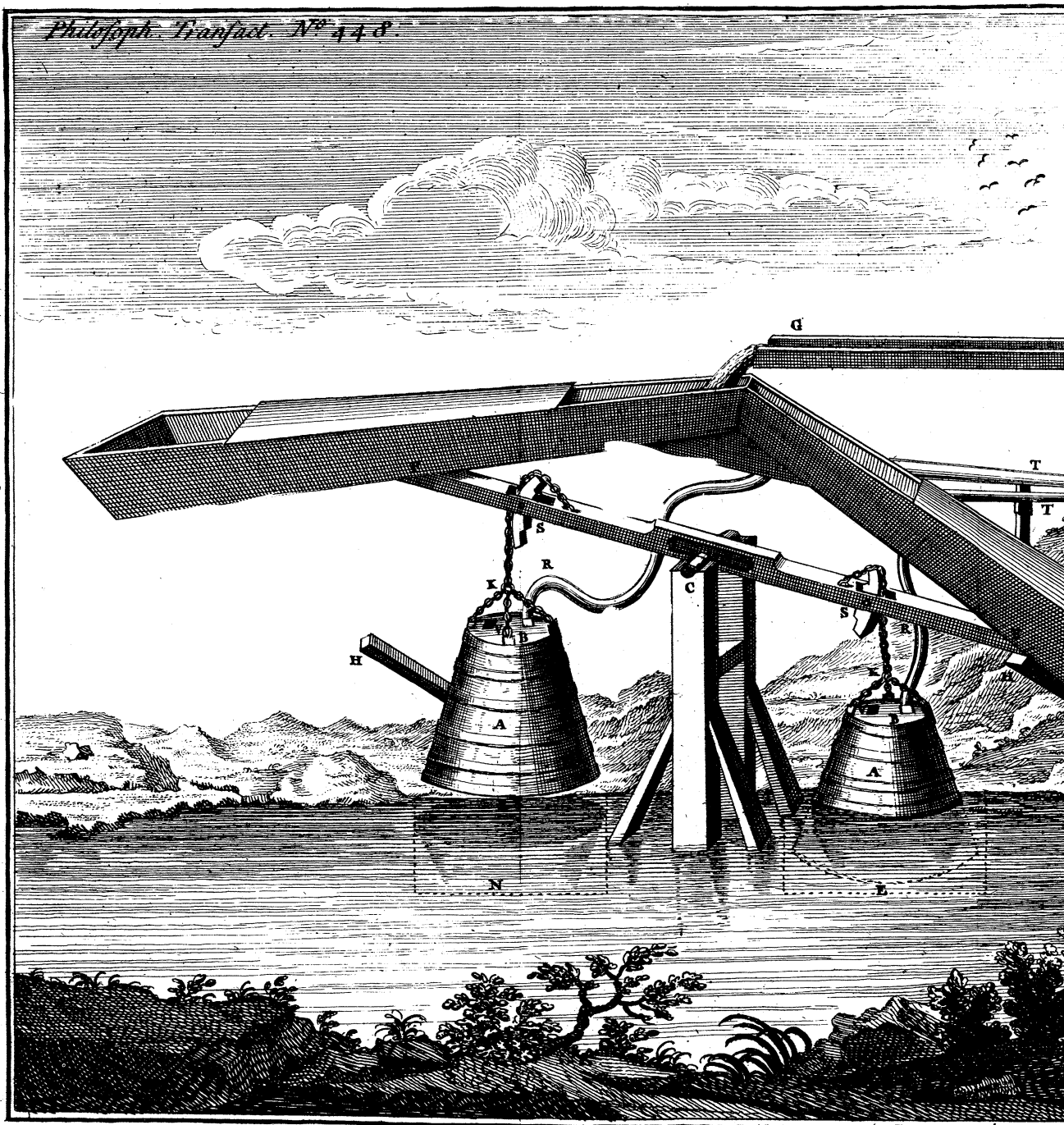
the Figure annex'd denotes; for in case one would not bestow Iron Hoops on the *Bellows*, they might be made square, in a Triangle, or any other Shape, provided they be as wide again at Bottom as at top; and if they be made of Wood, it will be necessary to provide an Edge round the Tops, for containing Stones or Leaden Weights, as much as will be found necessary to make them sink readily, when they are lower'd down into the Water.

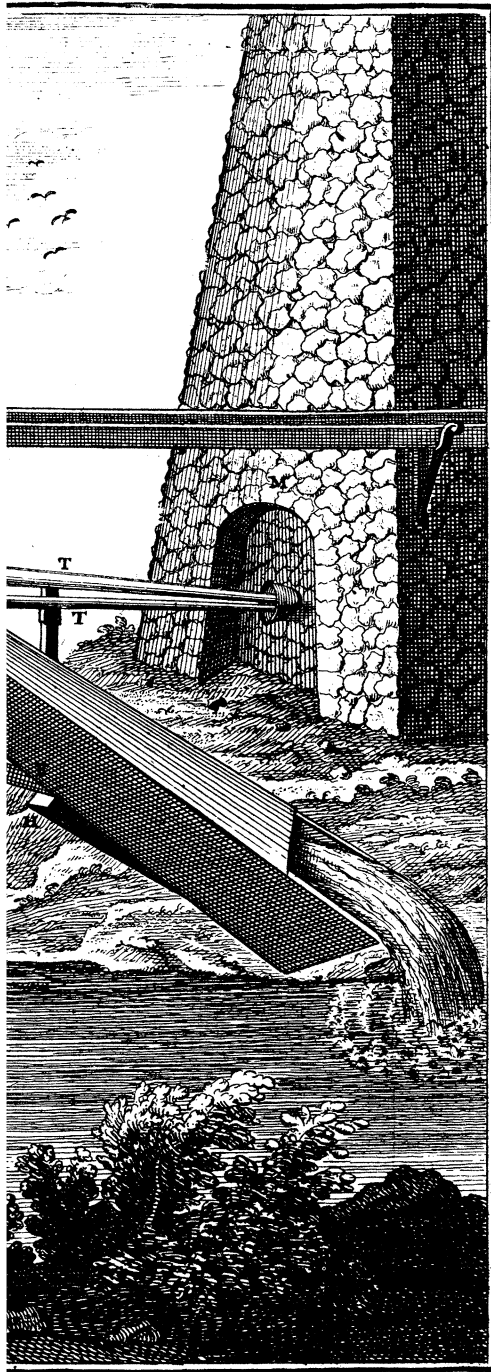
Lastly, If we will consider the Charge of those *Bellows* made use of at Iron Furnaces, as to the *Bellows* themselves, the Water-Wheel and its Axle-tree, &c. and compare the same with the Cost of these, we shall easily find a vast Difference, not to mention the vast Charges of keeping the common *Bellows* in Repair. But before I conclude, I think myself obliged to mention, that the Blast of these *Bellows* is govern'd and moderated in the same manner as the common ones, *viz.* by letting more or less Water into the sloping Gutters, and by taking out and letting in Plugs for that purpose placed in Holes near the Top of the *Water-Bellows*.

Stockholm,  
May 12. 1736.

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